

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
12 September 2002 (12.09.2002)

PCT

(10) International Publication Number  
WO 02/070151 A1

(51) International Patent Classification<sup>7</sup>: B09B 3/00,  
B09C 1/06, E21B 21/06

CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,  
SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ,  
VN, YU, ZA, ZM, ZW.

(21) International Application Number: PCT/CA02/00332

(84) Designated States (regional): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,  
GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent  
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,  
NE, SN, TD, TG).

(22) International Filing Date: 7 March 2002 (07.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/273,625 7 March 2001 (07.03.2001) US

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(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,

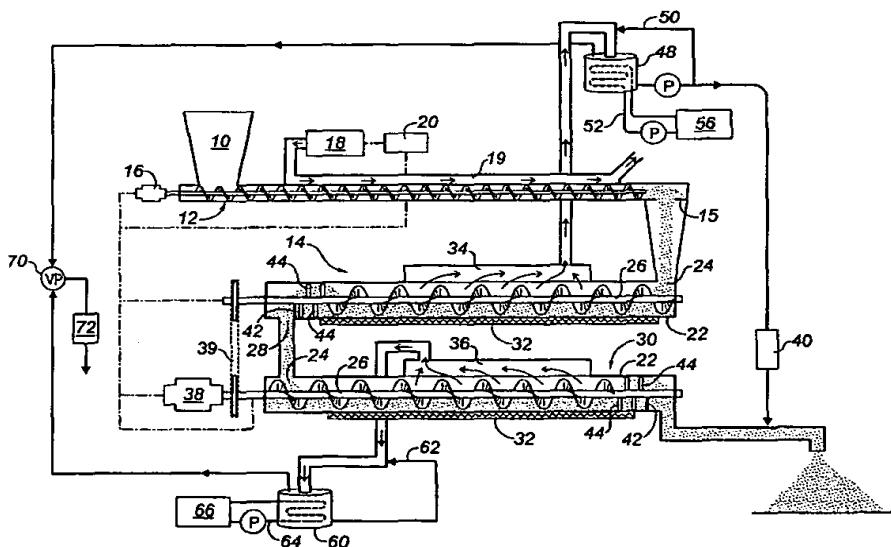
Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: AUGER CLEANING OF SOLIDS

RECEIVED  
JUL 18 2003  
GROUP 1700



WO 02/070151 A1

(57) Abstract: A system for cleaning particulate solids contaminated with hydrocarbons and water includes a preheating feed auger (12), a first separator (14) which comprises an auger (26) and a heat source, a first vapour collection and condensation system, a second separator (30) which comprises an auger (26) and a heat source which accepts the solids from the first separator and operates at a higher temperature, and a second vapour collection and condensation system. The system is particularly useful for cleaning solids obtained from drilling mud, which solids are mixed with water and diesel.

## AUGER CLEANING OF SOLIDS

### Field of the Invention

5        The present invention is relates to a method and apparatus for cleaning solids contaminated with volatile liquids and recovering the cleaned solids and volatile liquids.

### Background of the Invention

10       A drilling fluid, commonly referred to as drilling mud, is circulated through an oil well during the drilling process and performs many important functions. Drilling mud commonly has an oil base, such as diesel.

15       As drilling mud is circulated back to the surface, it is common to process the drilling mud with shale shakers, desanders and desilters to help remove cuttings and other solid impurities from the drilling mud. The cuttings and other solids removed from drilling mud are often contaminated with oil, diesel and other hydrocarbons. Because of environmental concerns, it is not possible to dispose of such solids without decontamination.

20       A variety of techniques have been suggested for dealing with this problem such as the use of surfactants, solvents and thermal operations to vapourize the hydrocarbons. Each of these methods has proven unsatisfactory for various reasons.

25       Therefore, there is a need in the art for methods and apparatuses to separately recover the solids, water and hydrocarbon components of contaminated solids recovered from used drilling mud.

**Summary of the Invention**

In one aspect, the invention comprises an apparatus for cleaning particulate solids mixed with at least a first liquid and a second liquid, wherein the first and second liquids

5 have different boiling points. The apparatus comprises:

(a) a first separator comprising:

- 10 i. an elongate cylindrical housing having an inlet and an outlet and defining a vapour collection opening;
- ii. an augur rotatably disposed within the housing,
- iii. means for heating the first separator;

(b) a second separator comprising:

- 15 i. an elongate cylindrical housing having an inlet and an outlet and defining a vapour collection opening;
- ii. an augur disposed within the housing;
- iii. means for heating the second separator;

20

(c) means for rotating the first and second augurs;

(d) a first vapour collector and condenser attached to the first housing for collecting and condensing vapour from the first separator; and

25

(e) a second vapour collector and condenser attached to the second housing for collecting and condensing vapour from the first separator;

wherein the outlet of the first separator is connected to the inlet of the second separator  
30 and the temperature of the first separator is maintained higher than the boiling point of

the first liquid but lower than the boiling point of the second liquid and the temperature of the second separator is maintained higher than the boiling point of the second liquid.

As used herein, "vapour" means the gases formed by the vapourization of the

5 liquids mixed with the solids upon heating.

In another aspect, the invention may comprise an apparatus for treating solids mixed with a first liquid and a second liquid, wherein the first and second liquids have different boiling points, comprising:

10

(a) first and second separators each comprising:

- i. an elongate cylindrical housing having an inlet and an outlet and defining a vapour collection outlet;
- 15 ii. an augur disposed within the housing, said augur having a discontinuous section near the outlet comprising solids churning means;
- iii. means for heating the first separator;

20

(b) means for driving each of the first and second separators;

wherein the outlet of the first separator is connected to the inlet of the second separator. Preferably, each housing includes a weir disposed across the housing adjacent the outlet for causing solids to form a blocking mass near the outlet of the housing.

25

In another aspect, the invention may comprise a method of cleaning particulate solids mixed with first and second liquids having different boiling points. The method may comprise the use of a first augur separator heated to temperature greater than the first boiling point but less than the second boiling point and a second augur separator 30 heated to a temperature greater than the second boiling point. The vapour driven from

the solids may then be recovered by separate vapour recovery and condensation systems connected to each of the first and second augur separators.

**Brief Description of the Drawings:**

5

The invention will now be described by way of an exemplary embodiment with reference to the accompanying simplified, diagrammatic, not-to-scale drawings. In the drawings:

- 10       Figure 1 is a schematic representation of one embodiment of a system of the present invention.

Figure 2 is a schematic plan view of the embodiment of Figure 1.

15       **Detailed Description:**

The present invention provides for a method and apparatus for processing solids mixed with water and hydrocarbon liquids. When describing the present invention, any term not defined herein has its common art-recognized meaning. While the invention

- 20       may be described in relation to processing solids recovered from drilling fluids contaminated with water and hydrocarbons, one skilled in the art may recognize that the invention may be used in connection with any particulate or granular solid matter (referred to herein as "solids") which is mixed with at least one liquid.

- 25       In general terms, the invention in its apparatus form comprises two separators connected in series. Each separator comprises an auger contained within a cylindrical housing where the solids are heated to vapourize the liquids. Each separator is connected to a vapour collection and condensation system.

- 30       Figure 1 is a schematic illustration of one embodiment of the invention. A general layout of the system in plan view is shown in Figure 2. The system may be

portable as it can be skid-mounted and therefore moved and reassembled quickly and conveniently. In this description, it is assumed that the solids are mixed with water and diesel oil, which have boiling points of 100°C and about 160°C respectively.

- 5        The solids to be cleaned are fed into a feed bin (10). From bin (10), the solids enter a feed auger (12) to be transported to the first separator (14). The feed auger (12) is preferably driven by a small electric motor (16). The apparatus includes a powerplant which consists of a diesel engine (18) powering an electric generator (20). The hot exhaust from the diesel engine (18) may be directed through a heat jacket (19) to heat the  
10      feed bin (10) and/or the feed auger, thereby preheating the solids as they are moved towards the first separator (14). Alternative means of preheating the solids in the feed auger, such as the use of electric heating elements, are of course possible. The solids then drop from auger (12) into the first separator (14). In one embodiment, a restriction plate (15) restricts the rate of solids entering the first separator (14) relative to the rate at  
15      which the auger processes the solids. The plate (15) also causes a buildup of solids at the feed intake of the first separator (14) that blocks the intake thereby blocking the escape of vapours from the first separator (14). The plate (15) may be removed if it causes the solids to block up excessively.
- 20       The first separator comprises a cylindrical housing (22) having an intake (24), a helical vane auger (26) and a solids outlet (28). The second separator (30) is similarly constructed.

25       In one embodiment, the first separator (14) is heated with electric heating elements (32) which may be disposed within the auger housing (22) or jacketed around the housing. Alternatively, waste exhaust heat from the diesel engine may also be used. In one embodiment, the auger shaft is hollow and the diesel engine exhaust is routed through the hollow auger shaft (not shown). The electrical heaters (32) are spaced along the auger housing (22) so that the temperature of the solids can be accurately controlled  
30      above the boiling point of the lowest volatile component, in this case water, but below the boiling point of the remaining liquid component, in this case diesel oil. As the solids

move along by auger (26) in the first separator (14) substantially all of the water and light hydrocarbons are boiled off.

The efficient removal of liquid from the solids in the first separator (14) depends

- 5 on the temperature to which the solids are heated and the dwell time of the solids in the separator. We have also found that the auger should preferably not be either too full or too empty. Good results may be obtained by regulating the flow of solids such that the auger is about half-full. As the purpose of the first auger is to boil the water while leaving the diesel oil component, a temperature of about 125° C to about 150° C is
- 10 appropriate. The dwell time may be adjusted by varying the speed of rotation of the auger or structurally by increasing or decreasing the length or diameter of the separator (14). Dwell times in the range of 2 minutes to 10 minutes are usually sufficient to substantially remove water from the solids.

- 15 The water and light ends which are removed in the first separator (14) are collected in vapour collection chamber (34) affixed to the auger housing. Preferably a broad opening through a substantial length of the top surface of the auger housing (22) is provided to allow vapour to escape into the collection chamber (34). From the collection chamber (34), the vapour is routed to a condensation system where the steam and other condensable gases are condensed into a water storage tank (48).
- 20

In both the first and second separators, the helical drive vane on the auger ends well before the discharge opening (28) and the auger housing includes a weir (42) across the bottom half of the housing. As a result, the solids fill the housing (22) completely,

- 25 substantially blocking it so vapors cannot escape out the outlet. The blocking action of the solids also prevents vapour from the second separator (30) from flowing back into the first separator (14). To stop the solids from compacting tightly, there are anti-compaction pins (44) which are attached to the auger shaft and radiate outwards. The pins (44) rotate in the solid material which accumulates at the end of auger (12) and stop the solid
- 30 material from compacting. These pins (44) may include blades or scrapers (not shown) connected to the end of the pins (44) and rotate near the housing wall. The pins or blades

are mechanical devices to churn the solids to stop compaction. The pins (20) may be simple rods or may have an oval blade-like cross-sectional configuration. Any mechanical configuration of pins (44) or blades which churns the solids and prevents compaction will suffice. The pins (44) or blades may or may not assist in actually  
5 moving the solids towards the outlet (28).

Because the solids are not compacted, they are continually pushed out of the first separator (14) and into transfer tube (31) that transfers the solid material to the second separator (30). The solids drop into the second separator (30) simply by force of gravity.

10

Once the solids enter the second separator (30) it is again heated in like or different manner as the first separator (14) but to a higher temperature. The temperature in the second separator should be sufficient to drive off all remaining liquid. In the case of diesel oil, a temperature of at least 160° is required and a much higher temperature is  
15 preferred. The temperature should not so high however so as to char or damage the solids.

The second separator (30) is preferably the same size and configuration as the first separator (14) and operates at the same speed and hence will be only half full of  
20 solid material, making it possible for volatiles that boil off to go to the second vapor collection chamber (36) and then to the hydrocarbon condensation system. In one embodiment, a single variable speed electric motor (38) rotates both first and second augurs (26) by a chain drive (39).

25 Once all volatiles have been boiled out of the solid material in the second separator (30), it is ready to be discharged. The driving helical vane of the second auger ends before the discharge outlet as with the first auger (26) and a weir (42) across the bottom half of the auger housing (22) is provided. Again, the solids may substantially plug the auger housing, stopping air from coming into the auger housing or any volatiles  
30 that are boiled off from escaping to the atmosphere. The second auger (26) has anti-compaction pins (44) and blades in like manner to the first auger (26) which rotate in the

solid material, stopping it from compacting. This allows the second auger to continuously push cleaned solids material from the separator (30).

Once the cleaned material leaves the second separator (30) it is ready to be reused  
5 or disposed of without environmental concerns. Water may be pumped from the water storage tank (48) through a filter (40) and used to wet the solids if that is necessary or desirable to facilitate further handling.

The steam and volatile light hydrocarbons that come off the first separator (14)  
10 may be condensed and stored in a water tank (48). Condensation occurs using pipes and a spray condensing system (50) which helps clean the water of fine solid material which may be carried over with the water vapor. The water that is collected may be cooled by a refrigeration system or simply by recirculating a closed loop of cooling fluid (52) through the water. The cooling fluid may be kept in a reservoir (54), pumped through a radiator with  
15 cooling fans (56) and then passed through the storage tanks to chill the water. The chilled water may then be sprayed as a fine mist into the incoming steam, preferably in the direction of the steam movement, to assist in the condensation process. The collected and stored water may also be used to dampen the solids prior to treatment so they are more easily handled.

20

Hydrocarbons that generally come off the second separator (30) may be condensed in a similar manner. Condensate stored in the hydrocarbon tank (60) may be chilled and sprayed (62) into the incoming vapour to assist in the condensation process. A closed loop of coolant (64) may be passed through cooling fans (66) and circulated  
25 within the storage tank (60) as is the case with the water tank (48). If the condensate is primarily diesel oil, it may be suitable for use as a fuel for the diesel engine (18) which powers the generator (20). Alternatively, a portion of the hydrocarbon condensate may be used in burners to supply heat to the augers (not shown).

30 The vapour from both the first and second separators may be drawn by the slight vacuum created by the condensation of vapour in the condensation system. In addition,

in a preferred embodiment, a small vacuum pump (70) may be provided to draw the vapours from the separators into the vapour condensation systems. As well, any uncondensable vapours will be drawn off by the vacuum pump and filtered through an activated charcoal filter (72) to remove volatile organic compounds.

5

The above described preferred embodiments are illustrative of the claimed invention and are not intended to be limiting. As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure may be made without departing from the scope of the invention. The various features

10 and elements of the described invention may be combined in a manner different from the combinations described or claimed herein, without departing from the scope of the invention.

**WHAT IS CLAIMED IS:**

1. An apparatus for cleaning particulate solids mixed with at least a first liquid and a second liquid, wherein the first and second liquids have different boiling points,  
5 said apparatus comprising:

(a) a first separator comprising:

- 10 i. an elongate cylindrical housing having an inlet and an outlet and defining a vapour collection opening;  
ii. an augur rotatably disposed within the housing;  
iii. means for heating the first separator;

(b) a second separator comprising:

- 15 i. an elongate cylindrical housing having an inlet and an oulet and defining a vapour collection opening;  
ii. an augur disposed within the housing;  
iii. means for heating the second separator;

20

(c) means for rotating the first and second augurs;

(d) a first vapour collector and condensor attached to the first housing for collecting and condensing vapour from the first separator; and

25

(e) a second vapour collector and condensor attached to the second housing for collecting and condensing vapour from the first separator;

30 wherein the outlet of the first separator is connected to the inlet of the second separator and the temperature of the first separator is maintained higher than the boiling point of the first liquid but lower than the boiling point of the second

liquid and the temperature of the second separator is maintained higher than the boiling point of the second liquid.

2. The apparatus of claim 1 further comprising a feed augur for directing the solids to the inlet of the first separator, wherein the feed augur comprises heating means for preheating the solids.  
5
3. The apparatus of claim 2 wherein the means for driving the first and second separators comprises at least one internal combustion motor.  
10
4. The apparatus of claim 2 wherein the means for driving the first and second separators comprises at least one electric motor.  
15
5. The apparatus of claim 4 further comprising an internal combustion motor driving an electric generator, wherein the electricity generated is used to drive the at least one electric motor, and wherein the internal combustion motor exhaust is used to heat one of or a combination of the feed augur, first separator and second separator.  
20
6. The apparatus of claims 1, 2, 3, 4 or 5 wherein the first separator augur and the second separator augur each comprise a discontinuous section at one end of the augur adjacent the separator outlet, and wherein each of the first and second separators comprise a weir adjacent the separator outlet.  
25
7. The apparatus of claim 5 wherein the one or both of the first augur and the second augur comprise a hollow shaft and the internal combustion motor exhaust is directed through one or both of the hollow shafts.  
30
8. An apparatus for treating solids mixed with a first liquid and a second liquid, wherein the first and second liquids have different boiling points, said apparatus comprising:

(a) first and second separators each comprising:

- i. an elongate cylindrical housing having an inlet and an outlet and defining a vapour collection outlet;
- 5 ii. an augur disposed within the housing, said augur having a discontinuous section near the outlet comprising solids churning means;
- iii. means for heating the first separator;

10

(b) means for driving each of the first and second separators;

wherein the outlet of the first separator is connected to the inlet of the second separator.

15

9. The apparatus of claim 8 further comprising a preheater connected to the inlet of the first separator for heating the solids and liquids mixture.
10. The apparatus of claim 9 wherein the preheater comprises a heated feed auger.
- 20 11. The apparatus of claim 8 wherein the first and second solids churning means comprises a plurality of pins extending radially outward from the augur shaft.
12. The apparatus of claim 11 wherein the first and second solids churning means further comprises a plurality of planar scrapers disposed on the outer ends of the pins.
- 25 13. The apparatus of claim 8 wherein the first separator comprises an intake restriction plate which limits the entry rate of solids into the first separator.

30

14. The apparatus of claim 8 wherein the first separator is maintained at a temperature higher than the boiling point of the first liquid but less than the boiling point of the second liquid and the second separator is maintained at a temperature higher than the boiling point of the second liquid.

5

15. The apparatus of claim 8 further comprising first means for collecting and condensing vapour generated by the first separator and second means for collecting and condensing vapour generated by the second separator.

10 16. The apparatus of claim 15 wherein the first and second condensation means each comprise means for cooling the condensate and spraying the condensate into the incoming vapour stream.

17. A method of cleaning particulate solids mixed with first and second liquids having different boiling points, comprising the steps of:

- 15
- (a) passing the solids through a first augur separator heated to a temperature greater than the first boiling point but less than the second boiling point;
  - (b) collecting and condensing the vapours from the first augur separator;

20

  - (c) passing the solids through a second augur separator heated to a temperature greater than the second boiling point; and
  - (d) collecting and condensing the vapours from the second augur separator; and
  - (e) recovering the clean, dried solids.

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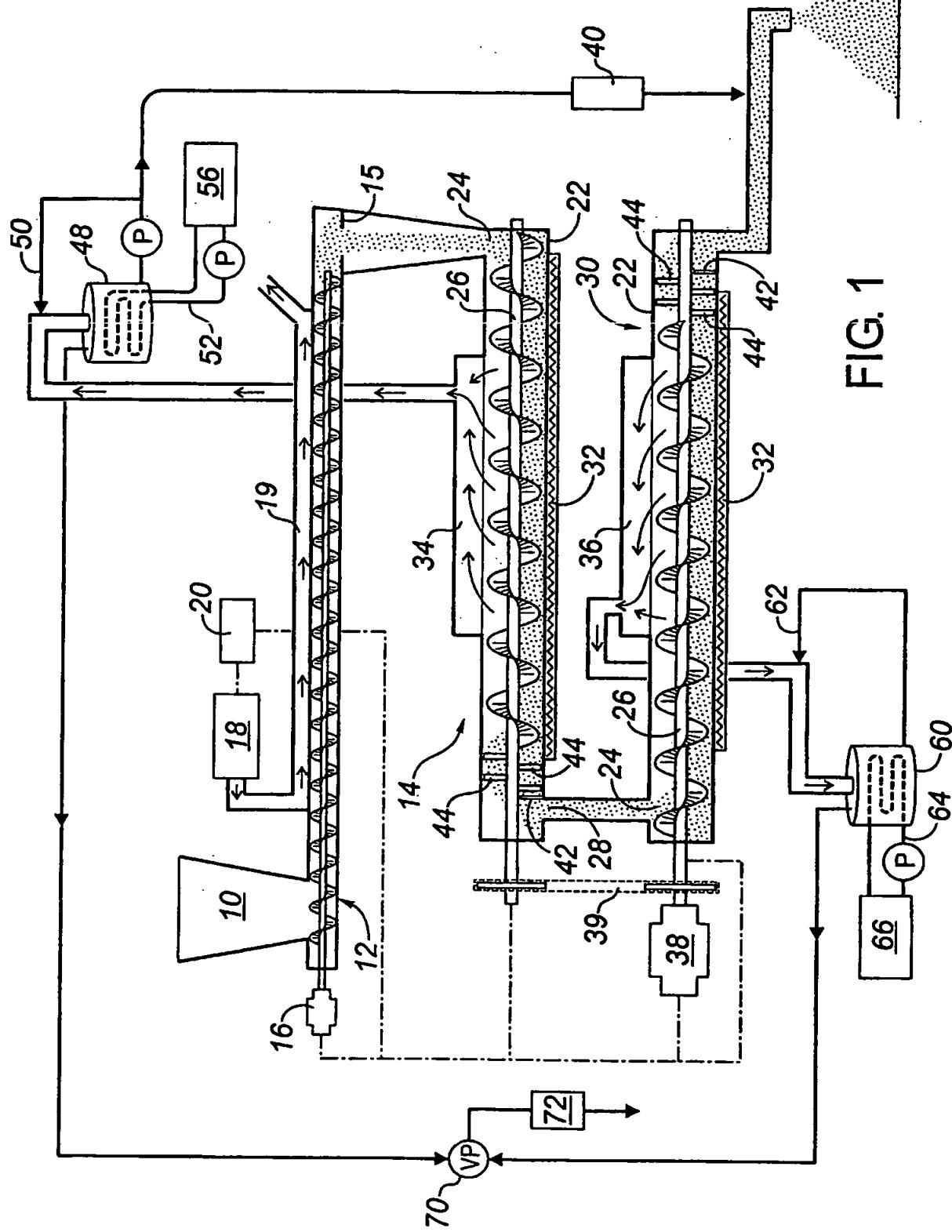
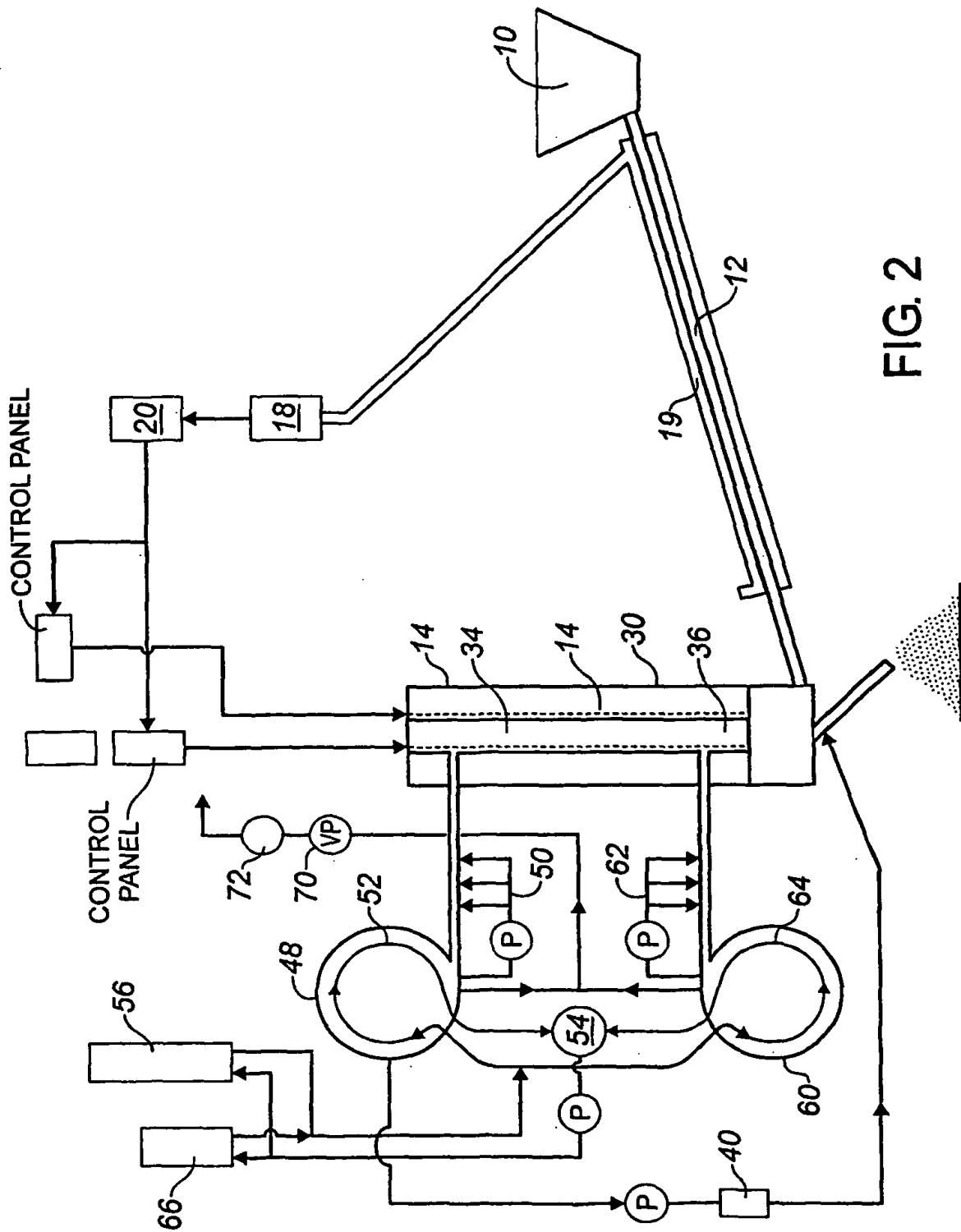


FIG. 1

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SUBSTITUTE SHEET (RULE 26)

## INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/CA 02/00332

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 B09B3/00 B09C1/06 E21B21/06

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**Minimum documentation searched (classification system followed by classification symbols)  
 IPC 7 B09B B09C E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 July 2002	17/07/2002
Name and mailing address of the ISA  European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer  Laval, J

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